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Participatory on Farm Evaluation of Improved Maize Varieties in Chilga District of North Western Ethiopia

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Abstract Participatory variety selection (PVS) trials were conducted in 2012 and 2013 in Chilga district of North West Ethiopia to evaluate the performance of improved maize (*Zea mayz* L.) varieties and to assess farmers' criteria for maize variety selection for future maize improvement. Six improved varieties including the local check were used for the study at four farmer villages: Anguaba, Serako and Eyaho. The experiment was laid out in a randomized complete block design and the trials were replicated over farmers' field in the three villages. The results of analysis revealed that a significant difference among the varieties for most the agronomic traits recorded except for grain yield which was not significant. With regard to location, no significant difference was observed for the majority of the traits except plant height and ear height indicating similarity in agro ecologies of the three villages. The results also revealed that farmers' preferences in some cases coincide with the researchers' selection. However, in general farmers have shown their own way of selecting a variety for their localities. These parameters include earliness, drought tolerance, grain yield, vigorousity, husk cover, cob size, grain color and grain size. Hence, it is a paramount important to include farmers' preferences in a variety selection process. Therefore, based on objectively measured traits, farmers' preferences and the agro ecologies of the site the varieties BH-540 and BHQPY-545 are recommended in the study area. The variety BHQPY-545 should be given high attention by the responsible body since it has quality protein content besides having favored traits in the study area.

Keywords Maize, Variety selection, Participatory, Grain yield

1. Introduction

Maize (*Zea mays* L) is one of the worlds' three primary cereal crops. It occupies an important position in world economy and trade as a food, feed and industrial grain crop. Maize holds a unique position in world agriculture as a food, feed for livestock and as a source of diverse, industrially important products. It accounts for 15-56% of the total daily calories of people in developing countries, and is currently produced on nearly 100 million hectares in 125 developing countries and is among the three most widely grown crops in 75 of those countries (FAOSTAT, 2010).

Maize is the most important food security crop for Ethiopia, as it is for many other countries in sub-Saharan Africa. The average annual rate of growth in area and yield has been increasing over the last four decades (FAOSTAT, 2008). Maize is one of the most important cereal crops in Ethiopia, ranking second in area coverage after teff and first in total production (CSA, 2013).

Varietal selections in maize in Ethiopian have usually been dominantly based on grain yield. Large numbers of breeding lines have been developed at various research stations and their performance evaluated across multi-location tests over several years and only a few varieties are so far identified. Varietal evaluation and decisions were only by researchers; however, this did not lead to the expected speed of variety release, or their dissemination afterwards. In addition, in developing new materials and extending them to farmers, classical plant breeding faces two major obstacles. First, new varieties can be disappointing to farmers where undesirable traits go undetected during the breeding process. Secondly, breeders necessarily discard many crosses and varieties during the selection process because of traits considered undesirable; however, these traits may actually be of interest to farmers. These illustrate the communication gap between researchers and farmers.

The importance and complex nature of agricultural research demands coordinated effort among biological scientists, extension agents and farmers in order to ensure that appropriate technology is developed and promoted (Rao *et al*., 2004).

Participatory plant breeding/selection has shown success in identifying more number of preferred varieties by farmers in shorter time (than the conventional system), in accelerating their dissemination and increasing cultivar diversity (Weltzien, E. *et al*., 2003). Therefore, adding

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information on farmers' perspectives of plant and grain trait preferences to these criteria will be helpful to the variety selection process. Research costs can be reduced and adoption rates increased if the farmers are allowed to participate in variety testing and selection (Yadaw *et al.*, 2006).

In Ethiopia, efforts have been made to develop and popularize improved varieties of maize through PVS. However, the farmers' selection criteria for improved varieties were not adequately assessed and well documented especially in the north west of Ethiopia. Therefore, the objectives of this study were to evaluate the performance of the released improved maize varieties through PVS and to assess farmers' selection criteria for future maize improvement work.

2. Materials and Methods

On- farm evaluations of improved maize varieties were conducted at Chilga district of North Western Ethiopia for two cropping seasons (2012 and 2013) under rain fed conditions in three locations. The locations are Anguaba, Serako and Eyaho farmer villages. Before starting the field work, selection of the host farmers was made based on their representativeness of the majority of smallholder farmers and their ability to disseminate the information to other farmers.

The experiment was laid out in randomized complete block design (RCBD) using each farmer's field as a replication. The maize varieties used in this study were BH-543, BHQPY-545, BH-660, BH-661, BH-670 and the local check, BH-540. Each experimental plot had 10×10m with a gross area of 100m^2. Spacing between plant to plant and row to row were 30 and 75 cm, respectively. The distance between plots was 1m. Two seeds per hill were sown, which were thinned to one plant per hill after three weeks. Sowing was done by hand drilling at a seeding rate of 25 kg ha^{-1}. Fertilizer in the form of urea and DAP was applied at the rate of 200 and 150 kg ha^{-1}, respectively. DAP was used all once during planting while urea was applied three times i.e. half during sowing and the one-fourth during 8-10 leaf stage and the remaining one- at silking stage. Weeding and other management practices were done as required.

Participatory evaluation methodology was used to acquaint the farming communities and extension workers with the improved maize varieties for facilitating their wider dissemination of the selected varieties in the future. The selection of the farmer's field was done in collaboration with development agents. Selection of individual farmer was made on meeting with key informants familiar about the crops to determine the adaptability and the growth performance of all maize technologies through the entire growing period. Group discussions were conducted to carefully build on and critically examine derived information from individual farmers of different households. Frequent monitoring of the trials by researchers and farmers was made throughout the cropping seasons to collect data on agronomic traits and farmers' assessments. Farmers evaluated the varieties throughout the growth period and at harvest by their own indigenous criteria they set. The criteria they used for evaluation was recorded. Scores were given on a scale from 1(very good) to 5 (very poor) for the criteria they set. The researchers' recorded agronomic data were subjected to the analysis of variance using Statistical Analysis Software (SAS, 1999). Farmers' selection data were analyzed using simple ranking method in accordance with the given value (De Boef and Thijssen, 2007).

3. Results and Discussion

3.1. Researchers' Evaluation

Table 1 shows mean square-values of researchers' evaluation of agronomic trait for the varieties, locations and error. Researchers evaluated the varieties based on yield and other agronomic traits. The varieties revealed a distinct statistical variation in all agronomic traits recorded except grain yield which is not significant. With regard to locations, most of the agronomic traits recorded shows statistically non significant. Plant height and ear height showed significant difference. This finding showed that though the varieties are replicated across the three villages to make the research representative to the study area, the villages are not agro-ecologically different from each other. This indicates that all the varieties responded similarly to the tested locations.

Table 2 shows researchers evaluation of the mean values of the different agronomic traits. The mean data indicated that maize varieties differ significantly in plant height (cm), ear height (cm), cob length (cm), number of grain rows cob^{-1} (no.), number of seeds row^{-1} (no.), total biomass yield (kg ha^{-1}) and harvest index. But the varieties did not differ significantly in grain yield (kg ha^{-1}).

Table 1. Mean square of yield and agronomic traits for the maize varieties planted at Chilga district of North West Ethiopia (2012 and 2013)

Source of variation	PH (cm)	EH (cm)	CL (cm)	GRC (No.)	SR (No.)	TBY (kg ha^{-1})	GY (kg ha^{-1})	HI
Variety	941.56**	975.52**	10.75*	1.89**	24.83**	26211662.6**	870642.32NS	0.0065**
Location	1276.22**	612.39**	1.26^{NS}	0.26^{NS}	0.37^{NS}	12721502.0^{NS}	1037385.39^{NS}	0.0007^{NS}
Error	141.56	106.19	2.01	0.11	2.92	3542235.9	718562.32	0.0009

NS- Non significant, *-Significant at 5%, **- Significant at 1%. (PH = plant height, EH = ear height, CL-cob length, GRC- number of grain rows/cob (No.), SR-number of seed/row, TBY-total biomass yield, GY=grain yield, HI = harvest index).

Table 2. Mean grain yield and agronomic data of maize varieties tested in three villages in Chilga district of North West Ethiopia (2012 and 2013)

Varieties	PH (cm)	EH (cm)	CL (cm)	GRC (No.)	SR (No.)	TBY (kg ha^{-1})	GY (kg ha^{-1})	HI
BH-540	192.0^{bc}	84.0^{cd}	18.77^{bc}	12.67^{c}	37.97^{bc}	14194^{b}	6014.3^{a}	0.424^{a}
BH-543	184.3^{c}	82.3^{cd}	18.30^{bc}	13.57^{b}	36.00^{cd}	19466^{a}	6410.7^{a}	0.327^{b}
BHQPY-545	200.0^{bc}	73.0^{d}	16.37^{c}	14.33^{a}	34.00^{d}	13617^{b}	5660.7^{a}	0.417^{a}
BH-660	228.0^{a}	122.3^{a}	20.83^{ab}	12.53^{c}	40.10^{ab}	19343^{a}	6931.7^{a}	0.360^{b}
BH-661	224.7^{a}	104.3^{ab}	20.43^{ab}	12.63^{c}	42.00^{a}	20348^{a}	6982.3^{a}	0.342^{b}
BH-670	212.3^{ab}	100.3^{bc}	21.40^{a}	12.23^{c}	39.10^{abc}	15710^{b}	6800.7^{a}	0.435^{a}
Mean	206.9	94.4	19.35	12.99	38.19	17113	6466.7	0.384
CV (%)	5.75	10.92	7.33	2.62	4.48	10.99	13.1	7.97
LSD (5%)	21.645	18.747	2.58	0.619	3.1117	3424	1542.2	0.0557

PH = plant height (cm), EH = ear height (cm), CL-cob length (cm), GRC- number of grain rows/cob (No.), SR-number of seeds/row (No.), TBY-total biomass yield (kg), GY = grain yield (kg), HI = harvest index. Means with the same letter within the same column are not significantly different.

The present result revealed that height of plant was highly significantly affected due to various maize varieties (Table 2). The tallest plants were observed in BH-660 (228.0cm) followed by BH-661 and BH-670 with height of 224.7 and 212.3 cm, respectively. The ear height ranged from 73.0 to 100.3 cm. The variety BH-660 with an ear height 122.3cm remained significantly superior among the varieties followed by BH-661 and BH-670 with a 104.3 and 100.3cm, respectively. Perusal of the data revealed that the tested varieties differed significantly for cob length (Table 2). Among the tested varieties, BH-670 had maximum cob length (21.40cm) followed by varieties BH-660 and BH-661 with the cob length of 20.83 and 20.43 and 20.8c cm, respectively.

Analysis of the data revealed significant variations among the tested varieties of maize for number of grain rows cob^{-1} (Table 2). The variety BHQPY-545 (14.33) had larger number of grains cob^{-1}, while BH-670 (12.23) had smaller number of grains cob^{-1}.

Mean values were significantly different for number of seeds row^{-1} (Table 2). BH-661 produced highest number of seeds row^{-1} having a value of 42.00, while least by BHQPY-545 (34.00). These results are in accordance with that of Sajid Ali *et al.* (2007), who also reported significant genetic differences for this parameter among maize genotypes. Analysis of the data regarding total biomass yield revealed significant differences for the parameter among the studied varieties (Table 2). According to the mean values BH-661 had higher total biomass yield (20348 kg ha^{-1}) followed by BH-543 and BH-660 with the values of 19466 and 19343 kg ha^{-1}, respectively.

In present investigations grain yield was found to be non significant (Table 2). Though the varieties are not statistically significant, BH-BH-661 had the highest grain yield (6982.3 kg ha^{-1}), while BHQPY-545 had the lowest grain yield (5660.7 kg ha^{-1}). The possible reason for the observed differences could be variation in their genetic makeup. Our results are in line with those of Mosisa and Habtamu (2007), who evaluated different improved maize varieties and reported that mean grain yield across environments varied from 4300 to 7300 kg ha^{-1}.

The variation in harvest index was highly significantly affected due to various maize genotypes (Table 2). The highest harvest index was noticed at variety BH-670 (0.435) followed by BH-540 (0.424) and BHQPY-545 (0.417) which remained superior among all others genotypes under study. This is in agreement with Mosisa and Habtamu (2007), who reported that mean harvest index among 20 germplasm lines varied from 31.1 to 45.0%. The research work reported by Nazir, H. *et al.* (2010) regarding harvest index in maize is similar to the present investigation.

3.2. Farmers' Evaluation

The farmers who participated and evaluated the trial were representative to the area and having long experience in farming. Before beginning of the selection process, selected farmers from the three villages were asked to set their priority selection criteria. Accordingly, earliness, drought tolerance, grain yield, vigorousity, husk cover, cob size, grain color and, grain size were identified as the most important farmers' selection criteria. Ranking of varieties were done on a scale of 1-5, 1 being very good and 5 being very poor.

Table 3-5 showed the three village farmers evaluation of the varieties based on the criteria they set. Anguaba village farmers (Table 3) varietal assessment showed that variety BH-540 was ranked highest (1.812), followed by BHQPY-545 and BH-543 with the same values of 1.875. Similarly Serako village farmers' evaluation of the varieties (Table 4) showed that their preferred varieties are BH-540, BHQPY-545 and BH-543 with the values of 1.750, 1.875 and 2.125, respectively. Eyaho village farmers' varietal assessment (Table 5) on the other hand showed BH-540 (2.000) is the preferred variety followed by BHQPY-545 and BH-670 with the values of 2.312 and 2.500 respectively.

Table 3. Anguaba Village Farmers Varietal Assessment Result in Chilga district of North West Ethiopia (2012 and 2013)

Criteria	Varieties					
	BH -540	BH-660	BH-661	BH-670	BH-543	BHQPY-545
Earliness	1	4	4	4	3.5	1
Drought tolerance	1	2.5	3	2	2	1
Grain yield	1.5	2.5	3	2.5	2	2
Vigorousity	1	1.5	1	3	1	1
Husk cover	2	1.5	3	2	1.5	1
Cob size	3.5	1.5	2.5	2	3	3.5
Grain color	2.5	1.5	1.5	1	1	1.5
Grain size	2	1	3	1	1	4
Overall score	14.5	16	21	17.5	15	15
Average score	1.812	2.000	2.625	2.187	1.875	1.875
Rank	1	4	6	5	3	2

Table 4. Serako Village Farmers Varietal Assessment Result in Chilga district of North West Ethiopia (2012 and 2013)

Criteria	Varieties					
	BH -540	BH-660	BH-661	BH-670	BH-543	BHQPY-545
Earliness	1.5	4	3.5	4	2.5	1
Drought tolerance	1	2.5	3	3	2.5	1
Grain yield	1.5	3	3	3.5	2	2
Vigorousity	1	1.5	2.5	3.5	1	1
Husk cover	1.5	1.5	3	1	1	1
Cob size	3	2.5	1	1.5	2.5	2
Grain color	2	2	1.5	1	2.5	3.5
Grain size	2.5	2	2	1	3	3.5
Overall score	14	19	19.5	18.5	17	15
Average score	1.750	2.375	2.437	2.312	2.125	1.875
Rank	1	5	6	4	3	2

Table 5. Eyaho Village Farmers Varietal Assessment Result in Chilga district of North West Ethiopia (2012 and 2013)

Criteria	Varieties					
	BH -540	BH-660	BH-661	BH-670	BH-543	BHQPY-545
Earliness	1.5	5	4.5	3.5	3	2
Drought tolerance	1.5	4	3	3	4.5	1
Grain yield	3	3	2.5	4	4.5	2.5
Vigorousity	2	1	1	3	1	1
Husk cover	1	2.5	4	3	1	1
Cob size	2	2.5	1	1.5	5	3.5
Grain color	3	2.5	1.5	1	3.5	3
Grain size	2	2	3	1	3.5	4.5
Overall score	16	22.5	20.5	20	26	18.5
Average score	2.000	2.812	2.562	2.500	3.250	2.312
Rank	1	5	4	3	6	2

Table 6. Farmers two years Average Varietal Assessment Result in Chilga district of North West Ethiopia (2012 and 2013)

Varieties	Anguaba Village	Serako Village	Eyaho Village	Average	Rank
BH-540	1.812	1.750	2.000	1.854	1
BH-660	2.000	2.375	2.812	2.396	4
BH-661	2.625	2.437	2.562	2.541	6
BH-670	2.187	2.312	2.500	2.333	3
BH-543	1.875	2.125	3.250	2.417	5
BHQPY-545	1.875	1.875	2.312	2.020	2

Table 6 showed mean value of the three village farmers for the studied varieties. As a result, the three village farmers combined result indicated that varieties BH-540, BHQPY-545 and BH-670 are the three best varieties with the values of 1.854, 2.02 and 2.333, respectively.

The rank given by researchers and farmers are compared below (Table 7). Table 7 below showed that researchers rank did not match with farmers rank except for the variety BH-670 which was ranked 3rd by both. This result clearly showed that farmers a major selection criterion is not yield rather combination of other non reproductive parameters. The present investigation confirms the observation by Bellon (2002) that farmers' perception about crop varieties are not always the same as researchers and if given the opportunity, farmers are able to express their preferences differently BH-540 and BHQPY-545 are early maturing varieties. This is in agreement with De Groote *et al*. (2002) who stated that there were growing interests among farmers in the use of early maize varieties in short rain fall season.

Table 7. Ranking of the varieties according to farmers and researchers

Varieties	Researchers' rank	Farmers' rank
BH-540	5	1
BH-543	4	5
BHQPY-545	6	2
BH-660	2	4
BH-661	1	6
BH-670	3	3

Scale: 1: Very good, 5: Very poor

The reasons behind farmers' preferences of BH-540 is attributed to its earliness associated with short rainy season, drought tolerance, comparable grain yield, and well field grain. The study site farmers' view about BHQPY-545 was generally positive. The good appreciation of the test, baking (as bread), malting as a local drink "tella", flour quality of the variety, resemblance in color with their indigenous variety which is already lost, its pop quality are all can be taken as a sign that farmers can easily accept improved varieties as long as it satisfies their basic preferences. This variety has double advantage as it contain high level of lysine and tryptophan and possesses some good levels of pro-vitamin A.

Through PVS, the farmers' situation, their preferences and their indigenous knowledge in setting criteria were well understood. It is also possible to consider farmers' evaluations and feedback and incorporate their preferences in the research processes. It was also able to ascertain that it is desirable to participate farmers in the maize improvement program from the very beginning and exploit their indigenous knowledge and their criteria for maize variety selection so as to develop farmer preferred varieties that can be easily and quickly disseminated to farmers.

4. Conclusions

Farmers may require multiple traits from one key crop such as maize. However, researchers may not know the traits that are important to farmers and vice versa. Participatory varietal selection has significant role in technology adaptation and dissemination in short time than conventional approach. In this investigation farmers' selection criteria was similar in the three villages and they were earliness, drought tolerance, grain yield, vigorousity, husk cover, cob size, grain color and, grain size. Based on the criteria they set, their preferred varieties were BH-540 and BHQPY-545. Researchers also recommend these two varieties for the study area based on the data analysis, agro ecologically suitability and the additional nutrient content of the quality protein maize (BHQPY-545). Therefore, farmers' varietal selection criteria should be taken into consideration during maize improvement programme.

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